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Applicant: **LGZ LANDIS & GYR ZUG AG**
CH 6301 Zug (CH)

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Inventor: **Heinrich-Peter Baltes**
Zeughausgasse 21
CH-6300 Zug (CH)

Inventor: **Michel Vincent Romorio**
14, Grand'Places
CH-1700 Fribourg (CH)

Kinoform.

Phase structure and manufacturing method for a kinoform which generates a single image after radiation with coherent rays. All image pixels are parts of a few picture spots of this image; their radiation intensity is almost constant within each picture spot and they have a limited number of levels, e.g., two. Such kinoform can be used as a genuineness feature for value documents.

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Kinoform

Application and Purpose

The invention pertains to a kinoform pursuant to the preamble of claim 1.

A kinoform of this type can be used, for example, as a synthetically manufactured, machine readable mark of genuineness for value documents.

Value documents in this meaning are, for example, bank-notes or bills, checks, stock certificates, identity papers or cards, credit cards, train tickets, admission tickets that are increasingly tested for genuineness by acceptance devices.

Most of these value documents can be forged with relative ease through modern reproduction devices. Numerous proposals are known aimed at storing genuineness information on such value documents that increase the difficulties for forgers and thus enhance safety from forging. Especially familiar are features with genuineness information in the form of optical marks, e.g., holograms that can be machine read.

State of the Art

From DE-PS 1 957 475, the kinoform is known as an occasional hologram replacement. The kinoform has the advantages of the hologram but does not have its disadvantages such as

- existence of several diffraction orders or their conjugates, respectively,
- low light yield

- extensive and time consuming computer us for computer controlled synthetic holograms.

Because no method has been found to date for generating a kinoform purely optically, it must be produced computer controlled and synthetically.

The calculation of such a traditional kinoform requires numerous discrete pixels distributed more or less regularly over the total surface of the desired image. The high number of pixels is normally an advantage for rendering a picture image like a photo, for example, because many pixels improve the image resolution.

In the case of machine readable optical genuineness features, however, this process is generally not applicable because the number M of pixels is small, e.g., $2<M<50$. The radiation intensity of M pixels represents here the M bits of an M bit code word where each pixel has two discrete light/dark values, for example. The code word does not necessarily have to be a binary code word but it can also have more than two discrete level values and be a ternary code word.

Task and Solution

The invention responds to the task of producing a kinoform that fulfills the following conditions:

- Ability to reproduce M discrete light/dark pixels of an image with $2<M<50$.
- Possibility that the M discreet light/dark pixels are additionally provided with a limited number of discrete gray values.

- Maximum conc ntration of the radiation energy of a coherent radiation source irradiating the kinoform in the few M discrete pixels.

The above task is solved with the invention by the features described in the preamble of claim 1.

<u>Description</u>

An exemplary embodiment of the invention is shown in the figures and will be described in greater detail below.

Fig. 1 shows an arrangement for reproducing an image by means of a kinoform,

Fig. 2 shows a diagram of the radiation intensity I of the pixels in the function of a solid angle δ.

A coherent radiation source (not shown) generates an even wave 1 of coherent radiation which lights a radiation permeable kinoform 2, for example. Its diffusion field reproduces in the familiar manner an image information, e.g., of the letter A, stored in the kinoform on the level of the image 3.

<u>Function Description</u>

The manufacturing process and the function are known from the cited state of the art.

Because only few M bits of a code word are present in the form of light/dark pixels with or without gray values in machine readable optical genuineness features in 2</-M</-50, the calculations described above in the cited state of the art are not easily realized. With so few

pixels, except for the case of M=1 which is of little interest in practice, maintaining the so-called kinoform condition, i.e., keeping the wave amplitudes or the radiation intensities, respectively, constant on the kinoform level is practically not possible with the traditional kinoform.

A statistic estimate of the relative deviation from this constancy shows that it is approximately equal $M_{-1/2}$. This indicates that only a high M value equal to several hundred pixels, such as M~/-300 keeps this deviation acceptably low.

Reading the pixels of the genuineness feature is generally done with photo detectors. In order to reach a kinoform with adequate quality despite the low M value, i.e., as a pure phase object, the non-infinitely small detector size is utilized and the requirement for spatial sharp focus of the M pixels is reduced. Each of the M pixels is replaced by a picture spot which consists of N discrete pixels with the approximately same radiation intensity as the original pixel replaced by the picture spot. The radiation intensity of the pixels within each picture spot is, therefore, approximately constant and the number N of the pixels to be selected per picture spot should be in the range of 50.

The difference between a traditional and the altered kinoform is shown in fig. 2. In this fig. 2, ð represents the solid angle of each pixel and I its radiance intensity.

Line a shows the image generated by a traditional kinoform. The corresponding kinoform is calculated on the basis of a high number M of binary pixels, for example, which are distributed more or less regularly over the total available solid angle.

Line b shows the initial pictur used for the production of th altered kinoform consisting of a small number of picture spots -- there are three picture spots in fig. 2. Each picture spot consist of N discreet pixels distributed more or less evenly over the space angle $\Delta\delta$ available for each picture spot. However, $\Delta\delta$ is not true to scale in fig. 2 but rendered extra large.

A kinoform is a pure phase structure that is calculated in the manner that it generates only diffracted rays of one diffraction order. Because the total radiation energy of the coherent radiation source is concentrated in this single diffraction order, the radiation yield efficiency is very high, generating a bright image. The total radiation energy of the coherent radiation source is concentrated in this manner in the few M picture spots with negligible energy loss.

To calculate a kinoform, the radiation amplitudes of the diffusion field in the individual picture spots of the image 3 in fig. 1 are determined first. Then, the progression of the wave amplitude is calculated in backward direction from the level of the image 3 to the kinoform level by means of am inverse fourier transformation. Any phase between zero and 2π is assigned to each point of the diffusion field. Each phase is assumed statistically as distributed at random with an even distribution thickness, for example. The points of the diffusion field are in this case the N discreet points of each of the M picture spots.

In practice, the N pixels are blurred by marginal effects or inaccuracies, for example, during the kinoform production; this is a desired effect in this instance.

PATENT CLAIMS

1. Kinoform generating a certain and single image by means of its diffusion field when irradiated with coherent radiation, characterized in that all pixels of the image are a part of a few picture spots of this image and that the radiation intensity of these pixels within each picture spot is approximately constant.

2. Process for generating a kinoform where the amplitude distribution function of a number of discrete picture spots of a certain and single image generated by the kinoform when irradiated with coherent radiation is detected, recorded and converted into a phase distribution function, characterized in that these pixels are parts of a few picture spots of that image and possess the approximate same radiation intensity within a picture spot.

3. Kinoform as described in claims 1 or 2, characterized in that the radiation intensity of all pixels of a picture spot has only two discrete light/dark values.

4. Kinoform as described in claims 1 or 2, characterized in that the radiation intensity of all pixels of a picture spot has more than two discrete level values.

5. Kinoform as described in one of the claims 1 through 4, characterized by its application as a genuineness feature of value documents.

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